



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ : C08L 23/16, 25/12, 33/12 C08L 51/04	A1	(11) International Publication Number: WO 88/ 05450 (43) International Publication Date: 28 July 1988 (28.07.88)
(21) International Application Number: PCT/US88/00174 (22) International Filing Date: 15 January 1988 (15.01.88) (31) Priority Application Number: 004,394 (32) Priority Date: 16 January 1987 (16.01.87) (33) Priority Country: US (71) Applicant: THE DOW CHEMICAL COMPANY [US/US]; 2030 Dow Center, Abbott Road, Midland, MI 48640 (US). (72) Inventor: HENTON, David, E. ; 5409 Woodview Pass, Midland, MI 48640-1967 (US). (74) Agent: MACLEOD, Roderick, B.; The Dow Chemical Company, P.O. Box 1967, Midland, MI 48641-1967 (US).		(81) Designated States: AT (European patent), AU, BE (European patent), BR, CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report.</i>
(54) Title: LOW GLOSS WEATHER AND IMPACT RESISTANT RESINS		
(57) Abstract Low gloss impact and weather resistant thermoplastic resins comprising a hard matrix polymer and a grafted alkylacrylate rubber having a core of a substantially uncrosslinked alkylacrylate polymer and a graftable overpolymer layer of a high crosslink density alkylacrylate polymer.		

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LOW GLOSS WEATHER AND IMPACT
RESISTANT RESINS

The present invention relates broadly to the preparation of molded resins that have low gloss. It also relates to an impact and weather resistant thermoplastic molding material comprising a blend of a polyacrylate rubber graft copolymer and a compatible rigid phase. More particularly, the present invention relates to such an impact and weather resistant thermoplastic molding material, wherein the polyacrylate rubber grafting base comprises a low gel, high swelling index butylacrylate rubber grafted with a rigid phase polymer.

Articles prepared from molded resins may be classified as having "high gloss" or "low gloss" according to whether their 60° Gardner gloss is above a value of 80 or below a value of 60. Most end use applications require either a high gloss or else a low gloss below 30, rather than a gloss in the intermediate range of 31 to 79. In addition, it is well known that it is desirable to obtain the appropriate gloss level without adversely affecting other desirable physical properties.

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It is previously known to prepare acrylate rubber polymers comprising homopolymers and copolymers of at least one alkyl acrylate having grafted thereto a suitable rigid phase. Preferred acrylate rubber particles comprise homopolymers of butylacrylate grafted with homopolymers of styrene or methylmethacrylate or copolymers of styrene with methylmethacrylate or acrylonitrile or both methylmethacrylate and acrylonitrile. Previously known weatherable resins modified by addition of the aforementioned butylacrylate containing rubbers have provided good physical properties and weather resistance, but generally have resulted in medium to high gloss articles under typical injection molding or extrusion conditions. For many applications, such as the interiors of automobiles and the like, it would be desirable to provide a weather resistant resin having a low gloss or "satin" surface appearance. Accordingly, it is to the attainment of this purpose, that the present invention is directed.

The preparation of impact resistant thermoplastic materials by mixing a "hard" component (a), comprising a copolymer styrene and acrylonitrile, with a "soft" component (b), comprising a graft copolymer of a styrene/acrylonitrile mixture onto a polyacrylate, has been disclosed in GB 1,124,911. Such molding materials are generically referred to as ASA polymers.

Numerous modifications and improvements in such ASA polymers have been developed. Suitable processes for the preparation of such improved ASA materials include those disclosed in U.S. Patents 4,442,263; 4,456,734; 3,830,878; and 3,661,994. The teachings of

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the above described United States Patents are herein incorporated in their entirety by reference thereto.

According to one broad aspect of the present invention, there is now provided an impact and weather resistant rubber-modified moldable thermoplastic resin comprising: (a) a hard matrix polymer comprising at least one polymer selected from the group of: polystyrene; polymethylmethacrylate; an addition polymer of two or more monomers selected from the group consisting of styrene, acrylonitrile, α -methylstyrene and methylmethacrylate; and mixtures thereof; and (b) a grafted alkylacrylate rubber comprising a rubber having a core of a substantially uncrosslinked alkylacrylate polymer having a T_g less than about 0°C , a swelling index in methyl ethyl ketone of greater than about 15, a gel content in methyl ethyl ketone of less than about 85 weight percent, and a graftable overpolymer layer of a high crosslink density alkylacrylate polymer, said rubber having grafted thereto at least one polymer selected from the group of polystyrene; polymethylmethacrylate, an addition polymer of two or more monomers selected from the group consisting of styrene, α -methylstyrene, acrylonitrile and methylmethacrylate; and mixtures thereof. It is preferred that component (b) be present in an amount of from 5 to 30 weight percent based on the total weight of the molding resin. It is also preferred that the gel content be less than 65 weight percent, and the swelling index be greater than 35.

In a second broad aspect of the invention there is provided a process for preparing a molded article

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having a 60° Gardner gloss of less than 60, which comprises molding the aforementioned resin.

5 The hard matrix polymer component of the present invented thermoplastic resins are well known to the skilled artisan. Preferred hard polymers are those well known thermoplastic resins used in injection molded applications. A particular preferred hard matrix polymer is styrene/acrylonitrile copolymer. The
10 hard matrix polymer may be prepared by any suitable polymerization technique including emulsion, mass, solution, or suspension polymerization techniques, or a combination thereof.

15 The grafted alkyl acrylate rubber is suitably prepared by emulsion polymerization techniques utilizing equipment and processing conditions well known to the skilled artisan. The core rubber is first prepared by polymerizing a suitable alkyl acrylate,
20 optionally in combination with a minor amount, i.e., up to about 20 percent by weight of a copolymerizable comonomer. Suitable alkyl acrylate monomers include the C₁₋₈ alkyl acrylates. A particularly preferred
25 alkyl acrylate monomer is butyl acrylate. Suitable copolymerizable comonomers include ethylenically unsaturated carboxylic acids and esters thereof having from 3 to 10 carbons and monovinylidene aromatic monomers. Preferably, the core consists essentially of
30 polymerized alkyl acrylate monomer.

In the emulsion polymerization, a suitable seed latex may be employed to achieve uniform latex particle size. Such seed latexes preferably are alkyl acrylate
35 homopolymers. Desirably, no polyfunctional cross-linkable monomer is intentionally added to the polymer-

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ization process, thereby achieving a substantially uncrosslinked alkyl acrylate core polymer rubber, however up to about 0.05 percent crosslinker can be added without significantly affecting the desired low gloss property of the present invention. Suitably, the core polymer has a particle size from 0.05 to 0.8 microns.

Once the core polymer is prepared, the graftable overpolymer layer is added by polymerization of an additional quantity of an alkyl acrylate monomer and a crosslinking or graftlinking comonomer. Suitable amounts of crosslinking or graftlinking comonomers are from 0.1 to 10 percent by weight.

Suitable crosslinking monomers are polyfunctional monomers that are well known in the prior art. Particularly preferred polyfunctional monomers are graftlinking divinyl-substituted monomers, wherein one or more of the vinyl groups is an allyl group or where one group is more reactive than the other under the polymerization conditions employed and a small portion of unreacted vinyl functionality remains after polymerization of the overpolymer layer as an aid to attaining graftlinking efficiency. Examples of suitable crosslinking monomers include divinylbenzene, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, mono-, di-, or polyalkylene- or polycycloalkylene glycol acrylates and methacrylates, butylene glycol diacrylate, butylene glycol dimethacrylate, etc.

Examples of suitable graftlinking monomers include allylacrylate, allylmethacrylate,

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diallylmaleate, diallylphthalate, triallyl isocyanurate, di-, or triallyl cyanurate.

5 While the alkyl acrylate rubber has been described as containing a core and a graftable overpolymer layer, due to the miscibility of the substantially uncrosslinked alkyl acrylate polymers and the overpolymer, the resulting composition does not necessarily comprise separate identifiable phases as
10 would be observable in a traditional "shell-core" morphology.

A final component of the grafted alkyl acrylate rubber is the grafted hard phase. The grafting
15 reaction is accomplished under well known graft promoting processing conditions. Preferably, the desired grafting polymer is polymerized in an emulsion process in the presence of the previously prepared alkyl acrylate rubber. Suitable grafting conditions
20 are employed to achieve at least some grafting of the hard phase to the alkyl acrylate rubber. Grafting levels measured as a ratio of weight of graft to weight of elastomer phase on the order of 0.01 to about 1.0
25 are desirable.

The above described components (a) and (b) may be separately prepared in the above described manner and later combined by melt blending, latex blending, or
30 other suitable techniques. Alternatively, at least some of component (a) may be prepared as a result of the grafting polymerization process. As is known to the skilled artisan, quantities of ungrafted matrix polymer are normally prepared in a grafting process.
35 However, additional quantities of separately prepared hard matrix polymer which may be the same or a

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different composition than the grafted polymer may be blended with the resulting composition.

Additional components, well known to be suitably employed in combination with thermoplastic resins, may be added to the present invented composition. Examples include antioxidants, colorants, pigments, plasticizers, flow aids, fire retardants, fillers, fibers, and structural reinforcing aids. In addition, other well known impact modifying elastomers may be added to the invented composition in order to provide uniquely tailored resultant properties (as in Examples 1A and 1B below). For example, the presently invented thermoplastic resins may be combined with additional weatherable impact modifiers, such as EP or EPDM rubbers as well as resins or resin blends containing such additional grafted elastomers. Also, conventional crosslinked and grafted acrylate elastomers or resin blends containing such elastomers may be added. The resulting impact and weather resistant thermoplastic according to the invention may be blended with additional thermoplastic matrix polymers such as vinyl chloride homopolymers and copolymers, polyphenylene oxides, polycarbonates, polyesters, aromatic polyester carbonates, and nylons.

The alkyl acrylate rubber may also be agglomerated into larger size particles utilizing previously known agglomeration technology before grafting if desired. Shear or acidification agglomeration techniques and the use of agglomerating agents including electrolytic and polymeric agglomerating agents such as those disclosed in U.S. Patent 4,419,496 are suitable.

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The resins of the invention may be molded using injection molding or other suitable thermoplastic molding techniques. The resulting molded objects typically possess a low gloss surface. Although the surface gloss may be somewhat dependent on the molding temperatures and type and design of the mold, the degree Gardner gloss of objects molded with the resins herein disclosed is consistently less than about 50 percent and often less than about 30 percent.

Having described the invention, the following Examples, Comparative Examples, and Proposed Examples are provided as further illustrative and are not to be construed as limiting. Unless indicated otherwise, parts, percentages and ratios are measured by weight.

Example 1.

Preparation A: Uncrosslinked Core Rubber

In a one gallon glass pipe reactor was placed 1030 g water, 2.70 g of NaHCO_3 , 1.80 g $\text{Na}_2\text{S}_2\text{O}_8$, 1.50 g acetic acid, and 13.8 g of a 1000Å butylacrylate seed latex (33 percent active). The contents were purged of oxygen and heated to 65°C while agitating at 150 RPM. When the temperature reached 65°C, a monomer conadd feed was started consisting of 900 g of n-butylacrylate added at a rate of 180 g/hr for 5 hours. An aqueous feed was added simultaneously at a rate of 135 g/hr for 5.25 hours and consisted of 0.932 percent sodium dodecylbenzene sulfonate soap (NDBS) in water. The latex was heated for 2.0 hours after the monomers had been added and then stabilized with 7.5 g of a 3/1 mixture of dilaurythiodipropionate/topanol CA⁹ antioxidant mixture. The resulting latex had a

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particle size of 0.44 μ and was about 50 percent soluble (i.e., had a gel content of about 50 percent) in tetrahydrofuran.

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Preparation B: High Crosslink Density Overpolymer Shell

5 Into a glass pipe reactor was placed 2436 g (810 g of rubber solids) of the core rubber latex of preparation A. An additional 100 g H₂O was added to
rinse the lines into the reactor. The reactor contents were purged of oxygen and heated to 65°C while agitating at 150 RPM. A monomer feed consisting of 92.6 g of
10 n-butylacrylate and allylmethacrylate (95/5) was added over a 1 hour period while an aqueous feed consisting of 119.8 g of water (99.0 percent), NDBS (0.74 percent), and Na₂S₂O₈ (0.26 percent) was added over a 2 hour period.

15 The latex was heated for an additional one hour after the aqueous feed had finished. The particle size of the resulting rubber was 4541Å. The gel content was 51 percent, and the swelling index was 31.2 in methyl ethyl ketone (MEK), when tested in accordance with well
20 known test procedures such as those essentially corresponding to those given in aforementioned U.S. Patent 3,830,878, at column 6, lines 17 to 31.

Preparation C: SAN Grafted Low Crosslink Density Alkyl Acrylate Rubber

25 Into a glass pipe reactor was placed 1485 g of latex prepared in preparation B (500 g) and 100 g of water. The contents of the reactor were purged of oxygen and the reactor heated to 65°C while agitating at 150 RPM. When the contents of the reactor were at 65°C, an aqueous and a monomer conadd feed were added at the same time. Over a 6 hour period, 500 g of acrylonitrile (75/25) was added along with a feed consisting of 98.4 percent

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Gloss

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H₂O, 1.20 percent NDBS, and 0.36 percent Na₂S₂O₈. The latex was heated for an additional 0.50 hour, steam stripped and stabilized with antioxidants. The resulting grafted alkyl acrylate rubber concentrate was isolated by freeze coagulation and air dried. The product contained 50.8 percent rubber and had a gel content of 51.4 percent in MEK. Because of the significant solubility of the rubber, the ratio of graft to rubber (G/R) could not be measured, but was estimated to be between 0.01 and 0.97.

Testing

Blends of the SAN grafted low crosslink density alkyl acrylate rubber of preparation C and various thermoplastic resins were prepared by compounding the rubber concentrate (RC) with other resins on a 0.8 inch Welding Engineers extruder. Samples were prepared by injection molding on a 2 oz. Negri Bossi injection molding machine (barrel temp 425/450°F, mold temp = 110°F). The 60° Gardner gloss was measured and is reported in Table I for Examples 1A and 1B.

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Table I

<u>Ex. No</u>	<u>Resin Blend</u>	<u>Ty¹</u>	<u>E²</u>	<u>Impact³</u>	<u>Gloss</u>
5 1A	Rovel [®] 401 (65.2%) ⁴ RC (19.7%) SAN 1(5.1%) ⁶	5200	67	10.3	26
10 1B	BA (27.9%) ⁵ RC (29.5%) SAN (42.6%) ⁶	4590	90	6.9	21

¹ Tensile Yield (lb/in²) ASTM 638 at 0.2 inches/minute

² Elongation at Rupture (%) ASTM 638 at 0.2 inches/minute

³ Notched Izod (ft-lbs/in notch) ASTM D-256

⁴ An EPDM rubber-modified SAN resin available from The Dow Chemical Company

⁵ A polybutylacrylate rubber-modified SAN resin. The acrylate rubber is a conventional homogeneous, crosslinked, rubber particle of volume average particle size, 0.15 μ , and contains 0.40% crosslinker and 1.0% graftlinker. The rubber particles are grafted with SAN. Rubber content is 53.8%.

⁶ Tyril[®] 111 brand styrene acrylonitrile copolymer available from The Dow Chemical Company.

It is seen that the resin blends of the invention possess good impact resistance and are well suited for the preparation of very low gloss molded objects.

Comparative Trials

The following Comparative Examples are not actual prior art. However, they help understanding of the surprising technical advance of the invention.

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Comparative Example 2A

5 This Comparative Example was essentially similar to Example 1A except that all the SAN-grafted rubber components were prepared with crosslinked cores. The product had a high gloss of 82 (rather than 26 as in Example 1A).

10 In particular, the "RC" component was prepared in a manner similar to Preparations A and B in Example 1, except for using polyvinyl crosslinkers in the core (about 0.25 percent) to get a rubber having 96.5 percent gel content and a swelling index of 6.3 in MEK. This rubber was then grafted with SAN as in Preparation 15 C in Example 1.

The resin was then blended, molded, and tested essentially as in Example 1, and the following results were obtained: Ty, 5720; E, 11; impact, 3.8; and gloss, 20 82.

Comparative Example 2B

25 This Comparative Example was essentially similar to Example 1B except that all the SAN-grafted rubber components were replaced by an equal amount of polybutylacrylate rubber-modified SAN resin. The product had a gloss of 62 (rather than a gloss of 21 as in Example 1B).

30 In particular, a polybutylacrylate rubber-modified SAN resin was prepared as in Comparative 2A. The rubber had 92.7 percent gel and swelling index of 8.4.

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The resin was then blended, molded, and tested essentially as in Example 1, and the following results were obtained: Ty, 5340; E, 30; impact, 2.9; gloss, 62.

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Proposed Examples 3A and 3B

From the results obtained in Examples 1 and 2, it is proposed that even lower gloss values might be obtained by using a complete absence of crosslinking in any of the acrylate rubber core. Thus, it is proposed that Examples 1A and 1B be repeated except that the use of crosslinking agent be omitted in preparing the polybutylacrylate rubber core.

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1. An impact and weather resistant rubber-modified moldable thermoplastic resin comprising: (a) a hard matrix polymer comprising at least one polymer selected from the group of: polystyrene; polymethylmethacrylate; an addition polymer of two or more monomers selected from the group consisting of styrene, acrylonitrile, α -methylstyrene and methylmethacrylate; and mixtures thereof; and (b) a grafted alkylacrylate rubber comprising a rubber having a core of a substantially uncrosslinked alkylacrylate polymer having a T_g less than about 0°C , a swelling index in methyl ethyl ketone of greater than about 15, a gel content in methyl ethyl ketone of less than about 85 weight percent, and a graftable overpolymer layer of a high crosslink density alkylacrylate polymer, said rubber having grafted thereto at least one polymer selected from the group of polystyrene; polymethylmethacrylate, an addition polymer of two or more monomers selected from the group consisting of styrene, α -methylstyrene, acrylonitrile and methylmethacrylate; and mixtures thereof.

2. A thermoplastic resin according to Claim 1, wherein the hard matrix polymer is a copolymer of styrene and acrylonitrile.

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3. A thermoplastic resin according to Claim 1, wherein the rubber core comprises a homopolymer of butylacrylate and has a gel content of less than 65 weight percent and a swelling index greater than 35; and component (b) is present in an amount of from 5 to 30 weight percent based on the total weight of the moldable resin.

4. A thermoplastic resin according to Claim 1, wherein the graftable overpolymer layer contains from 0.1 to 10 weight percent of one or more polymerized graftlinking or crosslinking monomers.

5. A thermoplastic resin according to Claim 4, wherein the graftlinking or crosslinking monomer is allylacrylate, allylmethacrylate or diallylmaleate.

6. A thermoplastic resin according to Claim 1, wherein the grafted alkylacrylate rubber has a copolymer of styrene and acrylonitrile grafted thereto.

7. A thermoplastic resin according to Claim 1 additionally comprising an EPDM rubber elastomer.

8. A thermoplastic resin according to Claim 1 additionally comprising a crosslinked and grafted acrylate elastomer.

9. The resin of Claim 1 which is capable of being molded into an article having a 60° Gardner Gloss of less than 60 when molded on a 2 oz. Negri Bossi injection molding machine at a barrel temperature of 425/450°F and a mold temperature of 110°F.

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10. The resin of Claim 9 which is capable of being molded into an article having a 60° Gardner Gloss of less than 30.

5 11. The resin of Claim 10 wherein the molded resin has a Notched Izod greater than 5 ft-lbs/inch notch as measured by ASTM D-256.

10 12. A process for preparing a molded article having a 60° Gardner Gloss of less than 60, which comprises molding the resin of Claim 1.

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INTERNATIONAL SEARCH REPORT

International Application No PCT/US88/00174

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³ According to International Patent Classification (IPC) or to both National Classification and IPC IPC(4) C08L23/16, 25/12, 33/12, 51/04 U.S. CL. 525/71, 75, 81, 82, 85, 304, 305, 308, 309, 902						
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Minimum Documentation Searched ⁴</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 30%; text-align: left; border-bottom: 1px solid black;">Classification System </th> <th style="width: 70%; text-align: left; border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border-bottom: 1px solid black;">U.S.</td> <td style="border-bottom: 1px solid black;">525/71, 75, 85, 86, 308, 902</td> </tr> </table> <div style="border-top: 1px solid black; padding-top: 5px;"> Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵ </div>			Classification System	Classification Symbols	U.S.	525/71, 75, 85, 86, 308, 902
Classification System	Classification Symbols					
U.S.	525/71, 75, 85, 86, 308, 902					
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴						
Category ⁶	Citation of Document, ¹⁰ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸				
X Y	US, A, 3,830,878 (KATO ET AL.) 20 AUGUST 1974. SEE THE ABSTRACT AND COLUMNS 3-5	1-6,9-12 7, 8				
Y	US, A, 4,585,832 (KOKUBA) 29 APRIL 1986 SEE COLUMNS 1, 2, 3 AND 5 AND CLAIMS 1 AND 4	7, 8				
A	US, A, 4,508,875 (KISHIDA ET AL.) 02 APRIL 1986					
A	US, A, 4,387,138 (GIFT) 07 JUNE 1983					
A	US, A, 3,992,485 (KOSUGI ET AL.) 16 NOVEMBER 1976					
A	US, A, 3,944,631 (YU ET AL.) 16 MARCH 1976					
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>[*] Special categories of cited documents: ¹³</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 50%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"d" document member of the same patent family</p> </div> </div>						
IV. CERTIFICATION						
Date of the Actual Completion of the International Search ¹ 07 MARCH 1988		Date of Mailing of this International Search Report ² 15 APR 1988				
International Searching Authority ¹ ISA/US		Signature of Authorized Officer ²⁰ <i>Carmen J. Securo</i> CARMAN J. SECURO				